Mammalogy Laboratory 1 - Mammalian Anatomy

I. The Goal.

The goal of the lab is to teach you skeletal anatomy of mammals. We will emphasize the skull because many of the taxonomically important characters are cranial characters. We will also demonstrate many of the differences that we've been discussing in lecture between mammals and other tetrapod groups. **You will be responsible for all the structures in bold**. The figure and key should be very helpful. In addition, be sure to check out the Animal Diversity Web at http://animaldiversity.ummz.umich.edu/accounts/Canis_lupus/specimens/.

II. The Cranium - exemplified by a coyote (*Canis latrans*) skull.

Two major regions of the skull may be recognized: the **brain case** and the **rostrum**. The brain case is the box of bone protecting the brain and the rostrum is the anterior region or the snout. The **auditory bullae** are associated with the brain case, and ventral to it; these house the middle and inner ears. The structure of the bullae varies greatly among mammals; this will be a useful taxonomic character.

The dorsal portion of the cranium is composed of a series of paired bones the meet along the midline. The long slender **nasal bones** form the roof of the nasal passages. Posterior to these are the paired **frontals**, which extend down the sides of the cranium to form the **orbit**, or eye socket. The **postorbital process** is a projection of the frontal that marks the posterior margin of the orbit. In many mammals (a horse, for example) this process extends all the way to the **zygomatic arch** to form a **postorbital bar**. Low **temporal ridges** arise on the frontals and continue posteriorly until they converge to form the **sagittal crest**. These ridges (including the sagittal crest) increase the area for attachment of jaw muscles. Posterior to the frontals, are the paired **parietals**. A small, unpaired **interparietal** is located between the posterior edges of the parietals. In *Canis*, this bone is fused with the **supraoccipital** (see below).

The entire posterior region of the skull is termed the **occiput** and is formed by a single bone called the **occipital**. The **foramen magnum**, through which the spinal cord passes, is located near the center of the occipital and is flanked by two knobs called the **occipital condyles**; these articulate with the **atlas**, the first of the cervical (neck) vertebrae. In embryonic mammals, four separate bones fuse to form the **single occipital bone** of the adult. The names of these embryonic bones are used to designate regions of the occipital bone. Around the foramen magnum, these are the ventral **basioccipital**, the dorsal **supraoccipital**, and lateral **exoccipitals**. The **occipital crests** extend laterally from the sagittal crest. Branches of the exoccipitals form the **paroccipital processes**, which extend ventrally in close association with the auditory bullae.

The tooth-bearing bones of the cranium are the paired **premaxillae** and **maxillae**. The premaxillae, which meet at the anterior end of the cranium, have two branches. The **palatal branches of the premaxillae** meet along the midline of the skull ventrally and form the anterior of **hard palate** or **secondary palate**. The **nasal branches of the premaxillae**

project dorsally and posteriorly to form the side of the **anterior (or external) nares**. Posterior to the premaxillae, the **maxillae** form the major portions of the sides of the rostrum and much of the secondary palate. A foramen in each maxilla is the anterior end of the **infraorbital canal**. Each of these terminates in the orbit and serves for the passage of blood vessels, nerves, and in some cases, muscle. This is a very important structure for rodent taxonomy; be sure you are familiar with it. Ventrally, the palatal branches of the premaxillae, maxillae, and the paired **palatine bones** form the **secondary** (**hard) palate** that separates the mouth from the nasal passage. The **incisive foramina** (or **anterior palatal foramina**) are a pair of openings at the suture between the maxillae and premaxillae.

Posterior and dorsal to the palatines is the opening of the nasal passage, the **internal nares**. The **vomer** is the unpaired bone that forms the septum between the two nasal passages. The highly convoluted bones within the nasal passages are the **turbinates**. Posterior to the internal nares and palatines are the paired **pterygoids**. Between the pterygoids and posterior to the vomer is the unpaired **presphenoid**. This complex bone passes beneath the pterygoids, palatines and maxillae to reappear dorsally in the wall of each orbit, where it is termed the **orbitosphenoid**. The medial **basisphenoid** lies between the basioccipital and the visible portion of the presphenoid.

The conspicuous bony arches forming the lateral border of the orbits and the **temporal fenestrae** are the **zygomatic arches**. Three bones contribute to the zygomatic arches. Anteriorly, the zygomatic process of the **maxilla** (often very small) articulates with the **jugal**. Posteriorly, the jugal articulates with the zygomatic process of the **squamosal bone**. On the ventral side of the base of each zygomatic process of the squamosal, the **mandibular fossa** provides an articulation point for the lower jaw.

Between the jugal and frontal bones, at the anterior root of the zygomatic arch is the small **lacrimal bone**, the opening in which is for the passage of the **tear duct**. Anterior to the squamosal, and posterior to the frontal and **orbitosphenoid** is the **alisphenoid bone**. The opening in this bone is the **alisphenoid canal**.

As mentioned above, the bulbous structure between the mandibular fossa and the occipital condyle is the **auditory bulla**. Its opening is called the **external auditory meatus**, across which stretches the eardrum or **tympanum**. In *Canis*, the bulla is formed entirely by the **tympanic bone**, but in some mammals, the **entotympanic bone** is also visible externally. Within each auditory bulla, there are three ear ossicles: the **maleus**, **incus**, and **stapes**. In some mammals (pigs for example), **mastoid processes** are present lateral to the paroccipital processes. In many mammals, the tympanic and squamosal bones fuse; the product of this fusion is the temporal bone. This is the case in cats and humans (hence the human jaw joint is called the temporal-mandibular joint).

III. The Mandible.

Compared to the cranium, the mandible is a very simple structure. In mammals, the mandible is formed from a pair of **dentary bones**. At the anterior end of the mandible, these bones articulate with each other at the **mandibular symphysis**. This structure is firmly fused

in *Canis* and *Homo*, but in many mammals the dentaries are easily disarticulated. The **mandibular condyle** is the portion of the dentary that articulates with the mandibular fossa of the squamosal. Dorsal to the condyle, the **coronoid process** extends up into the temporal fenestra and provides leverage for jaw musculature. Ventral to the condyle, the **angular process** protrudes posteriorly. The shallow depression near the base of these processes is the **masseteric fossa**. In some mammals (not in *Canis*), the masseteric fossa actually perforates the dentary; in those forms, the opening that results is called the masseteric canal.

IV. Post-Cranial Skeleton.

Pectoral Limb. The shoulder, or **pectoral girdle**, of most mammals is composed of two elements, the **scapula** and the **clavicle**. The scapula is embedded in muscles dorsal to the ribs and has no direct articulation with the vertebral column. The clavicle extends from **the acromion process of the scapula** to the **sternum** and provides a firm brace for the anterior limb. Most mammals that run on hard ground have a reduced clavicle or lack a clavicle altogether. In these forms, there is no direct connection between the anterior limb and the axial skeleton; rather the anterior limb is suspended in a sling of musculature that absorbs the shock generated by running. Monotremes retain the early synapsid state of the pectoral girdle, with a scapula and clavicle, plus an interclavicle and anterior and posterior coracoids.

The pectoral limb is composed of a series of articulating bones. The proximal **humerus** has a large head that articulates with the **glenoid fossa**, a cup shaped structure on the **coracoid process of the scapula**. This results in a ball-and-socket joint that allows great mobility of the limb in several planes. The humerus articulates distally with the two bones of the lower forelimb, the **radius** and the **ulna**. This hinge joint is termed the elbow and allows movement in only one plane. The **olecranon process of the ulna** extends beyond the humerus and serves as the lever for the triceps muscles that straighten the forelimb. The radius is the more medial of the two elements and articulates at both ends in a manner that allows the two bones (the radius and ulna) to rotate around each other. Distal to these elements are the **carpals**, or wrist bones.

Primitively, mammals are **pentadactyl**; that is, they have five digits. Reduction in the number of digits occurs frequently. The bones distal to the carpals are the elongate **metacarpals**; there is one for each digit. These are enclosed within the forefoot or palm. Each digit is composed of a series of **phalanges**. The thumb (the medial digit) is called the **pollux**. The entire forefoot or hand is termed the **manus**.

Pelvic Limb. The hip, or **pelvic girdle**, is a single structure that is formed by the fusion of three pairs of bones. The dorsal **ilium** articulates with the **sacral vertebrae**. The **ischium** is directed posteriorly and forms the bony part of the rump. The **pubic bones** project anteriorly and ventrally and are jointed at their distal ends; this joint is termed the **pubic symphysis**. These three pairs of bones, together with the sacral vertebrae form a ring through which the digestive, urinary, and reproductive tracts exit the body. In females of some species, the pubic symphysis is somewhat elastic to allow for passage of a large fetus. In monotremes, the three pairs of bones do not fuse; they retain the ancestral condition. In marsupials and monotremes, there is an additional pair of bones, the **epipubic bones**, extending anteriorly from the pubic region of the pelvis.

The structure of the hind limb is similar to that of the forelimb. At the point where the three elements of the pelvis meet, there is a large socket, the acetabulum, which articulates with the head of the **femur**, the proximal element of the hind limb. The **fibula** and **tibia** are distal to the femur. The medial of these, the tibia, is the larger in most mammals and the fibula is often greatly reduced. While the elbow bends to project the forelimb anteriorly, the knee bends to project the hind limb posteriorly. The **patella**, or kneecap, develops in a tendon (the patellar tendon) on the ventral side of this joint. Distal to the two elements of the lower hind limb are the ankle bones, or **tarsals**. One of these, the **calcaneum** extends dorsally to provide leverage for the calf muscles via the Achilles' tendon. The bones distal to the tarsals are the **metatarsals**, and there is one per digit. As in the manus, the bones that form the digits in the foot (**pes**) are called **phalanges**. The medial digit is termed the **hallux**.

Axial Skeleton. There are five groups of vertebrae in mammals. The most anterior group is the **cervical vertebrae**. With very few exceptions, mammals have 7 cervical vertebrae, all of which lack ribs (except in monotremes). **Thoracic vertebrae**, bearing **ribs**, follow the cervical vertebrae; the **lumbar vertebrae** follow the thoracic and have vestigial ribs fused to them to form **transverse processes**. The number of both thoracic and lumbar vertebrae varies among mammals. The **sacral vertebrae** follow the lumbars, and as mentioned above, are firmly fused to form a solid point of attachment, **the sacrum**, for the pelvic girdle.

The **sternum** is composed of a number of ossified segments. The first of these is called the **manubrium**; this is keeled in bats, though not to the extent seen in birds. The last sternal segment that ossifies is called the **xiphisternum** and those segments between this and the manubrium comprise the **body of the sternum**. A cartilaginous process, the **xiphoid process** extends posteriorly to the xiphisternum.

V. Exercises - There are several stations set up around the lab. Be sure to visit each of them.

Station 1. There are several dog (*Canis*) skulls. Triple up, take one to your bench and identify the structures in **bold** in the above description of cranial anatomy. You will be responsible for these on the quiz.

Station 2. There are two cat (*Felis*) skeletons at this station. Learn the bones in **bold** in the description of postcranial anatomy above. You will be responsible for these on the quiz.

Station 3. There is a kangaroo (*Macropus*) and an opossum (*Didelphis*) skeleton at this station. Note the **epipubic bones** associated with the pelvic girdle. The kangaroo skeleton also exhibits the **reduction of the fibula** to the point that it's little more than a splint of bone.

Station 4. There is a sloth (*Bradypus*) skeleton at this station. This is an arboreal form that has a very robust clavicle. Compare the clavicle with that of the cat skeleton.

Station 5. There are several skulls here.

The first is a turtle skull. Notice the robust shield of bone in the temporal region. This represents the **anapsid** condition of "stem reptiles." In addition, notice that there are several bones in each mandible; the dentary is the most anterior of these. Also notice that there are two occipital condyles (obviously this is not a unique trait of mammals).

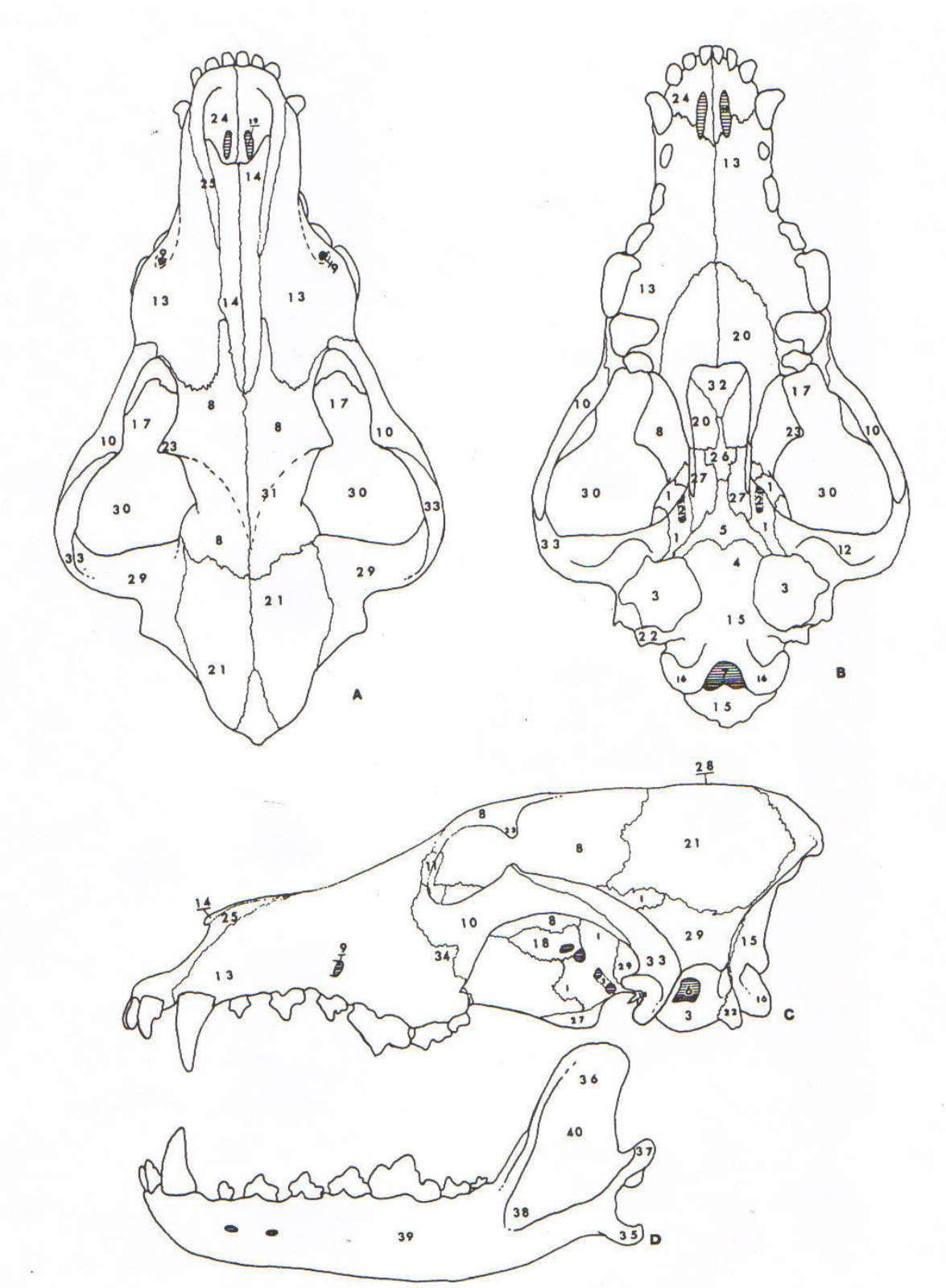
The second skull is a crocodilian (alligator) skull. This skull illustrates the diapsid condition; notice the two temporal fenestrae. Also notice that there is a secondary palate, two external nares, a single occipital condyle and several post-dentary bones in the mandible.

The next two skulls are from a bird and a lizard. Each of these represents a different modification of the diapsid temporal condition. The lizard has lost the lower arch of bone, whereas the bird has lost the middle arch.

The final skull is a horse (*Equus*) skull. Again, notice the temporal region. The outline of the original **temporal fenestra** is visible.

Key to Figure 1:

1. alisphenoid bone
2. alisphenoid canal
3. auditory bulla – tympanic bone
4. basioccipital
5. basisphenoid
6. external auditory meatus
7. foramen magnum
8. frontal
9. infraorbital canal
10. jugal
11. lacrimal
12. mandibualr fossa
13. maxilla
14. nasal bone
15. occipital bone
16. occipital condyle
17. orbit
18. orbitosphenoid
19. incisive foramen
20. palatine
21. parietal
22. paroccipital process
23. postorbital process (frontal bone)
24. premaxilla, palatal branch
25. premaxilla, nasal branch
26. presphenoid
27. pterygoid
28. saggital crest
29. squamosal
30. temporal fenestra
31. temporal ridge
32. vomer
33. zygomatic process of squamosal bone
34. zygomatic process of maxilla
35. angular process
36. coronoid process
37. mandibular condyle
38. masseteric fossa
39. body
40. ramus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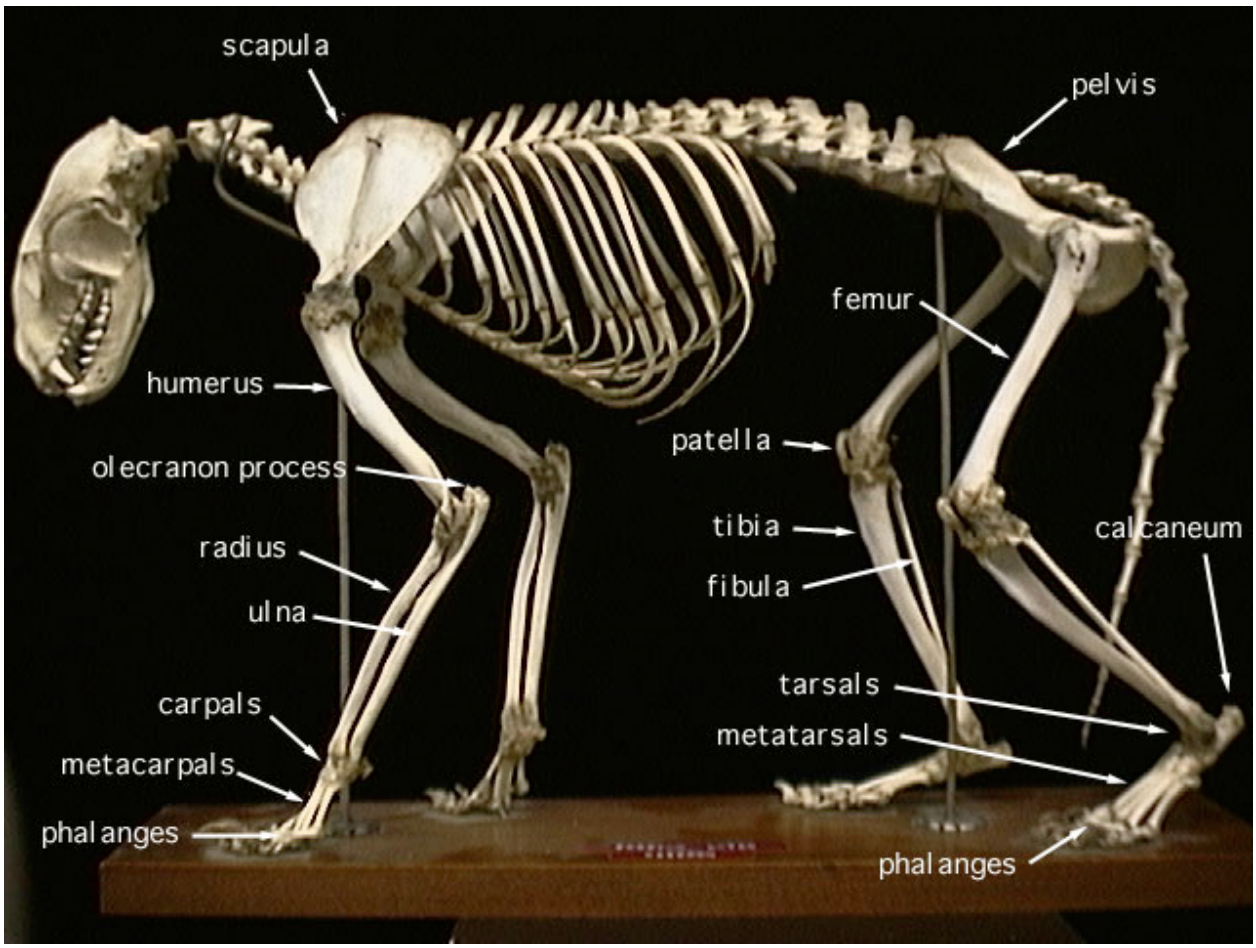
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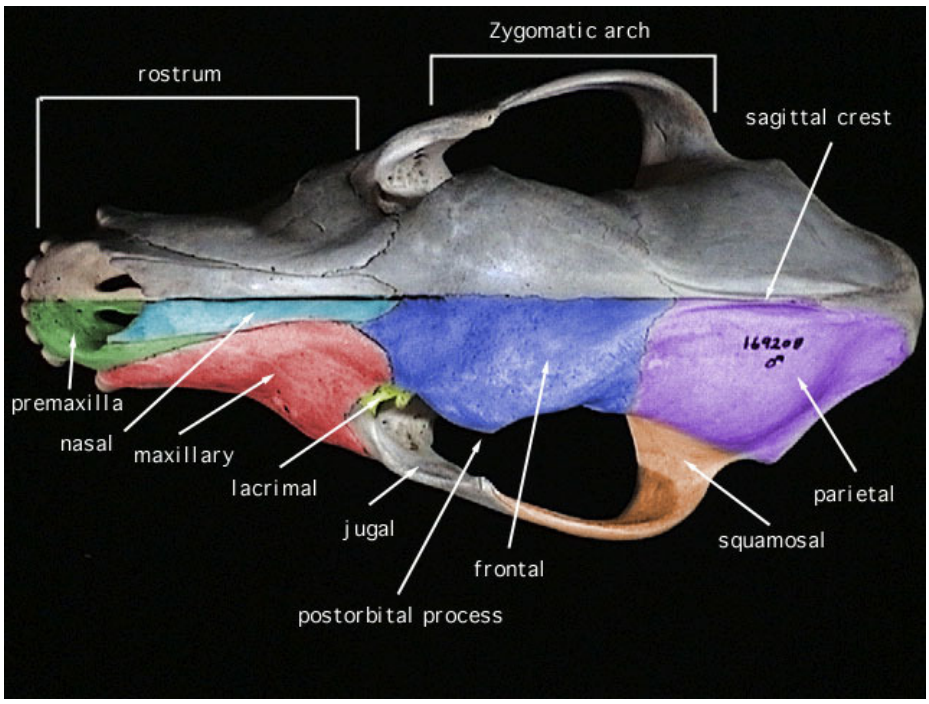
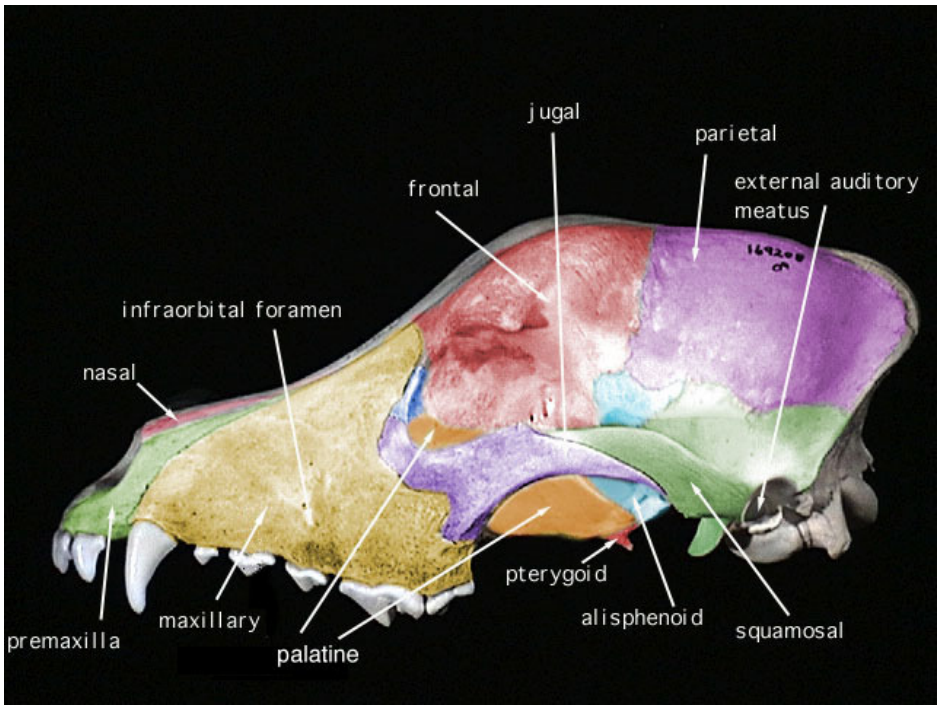

Zygomatic arch
rostrum
sagittal crest
premaxilla
nasal
maxillary
lacrimal
jugal
frontal
postorbital process
parietal
squamosal


jugal
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nasal
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alisphenoid
squamosal
maxillary
premaxilla
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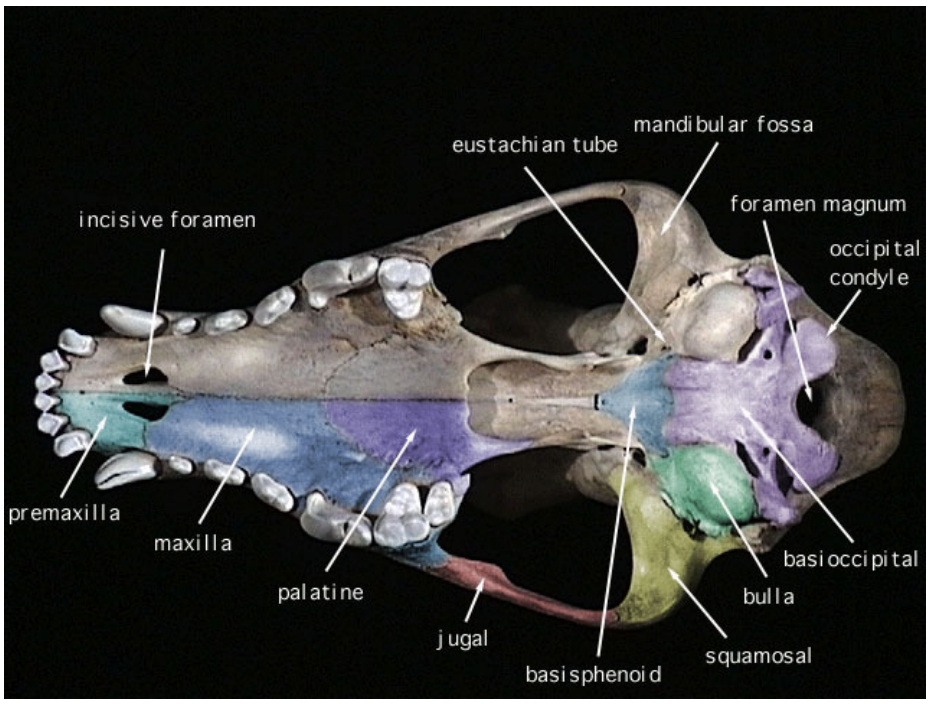
mandibular fossa
eustachian tube
foramen magnum
incisive foramen
occipital condyle
premaxilla
maxilla
palatine
basioccipital
bulla
jugal
squamosal
basisphenoid